Pre-Classroom Activities

Activity: Angles and Electricity

Article: Beaming Down Energy

Here's a current events quiz: Why is the cost of energy— electricity, gasoline, and natural gas— increasing so rapidly? Can we anticipate any relief? What's NASA doing to help the problem?

The United States Congress has asked NASA to explore inexpensive and efficient answers concerning energy conservation, and the big answer appears to be solar energy. Don't we already know all about solar energy? Aren't there already solar collection panels scattered across the country? Would it be reasonable to say that solar energy isn't a major factor in the consumer energy business? The answer to all three questions is yes, but don't let that stop you. The solar energy NASA is exploring isn't anything like the solar energy you may be thinking of.

Space Solar Power (SSP) involves collecting solar energy in space from a constellation of solar power satellites, converting it to electricity, and beaming it down to Earth instead of using solar collectors on Earth. SSP addresses several key concerns, has generated various concepts for different levels of power demands, has achieved many technological innovations over conventional solar energy plans, and it and proposes promising solutions.

Earth-based Solar Energy Is Inefficient

Collecting solar energy on Earth is inefficient. Less than 50 percent of the Sun's energy can be used to create electricity for us on Earth. Scientists at several NASA centers have attacked this problem and found ways to make solar power more energy efficient.

Because most energy is currently obtained from the blue part of the light spectrum, scientists have built large prisms to separate bands of the light

spectrum, so they can "harvest" energy from the various wavelengths that constitute white light.

Scientists also know that solar energy reaching the Earth is dependant on atmospheric conditions. If the weather is cloudy or stormy, not nearly as much solar energy will be able to make its way down to solar collection panels on Earth. Customers purchasing electricity want reliable, consistent power.

If the solar collection devices are moved from rooftops to satellites stationed above the clouds over Earth, the atmospheric variable is eliminated, so unobstructed solar energy can be collected. Concentrators can focus the sun's energy on photovoltaic arrays hovering just above the Earth. The energy can be converted to microwave or laser beams and sent back to Earth. Just as cell phones and television satellite dishes receive their signals directly from space, solar energy consumers— whether they're powering a hybrid electric-gas automobile engine or a house's electric-gas utilities— can access the power 24 hours a day. They'd contract the energy services through a service provider who installs the hookups- just like cell phones and satellite dishes.

With the combination of high-density concentrators, thin film prisms, and innovative multi-band gap photovoltaic concepts, 44 percent of the Sun's energy can be converted to electricity. The remaining energy remains as heat. Using recent breakthroughs in thermo-photovoltaic study, 15 percent of the heat can be converted to energy. That removes heat from the photovoltaic array. Scientists expect that solar satellites could extract close to 65 percent of the Sun's energy in the foreseeable future.

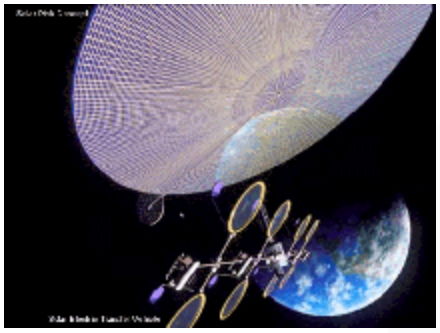
Earth-Based Solar Energy is Expensive

Solar energy is fairly expensive, because the solar arrays and collectors are so costly to produce and install. A photovoltaic cell costs approximately $200 per square inch, for example. In 2000, solar energy cost approximately $0.80 to $1.00 per kilowatt-hour, compared to $0.06 for coal, natural gas or high sulphur gas. There was little incentive for customers or industry to switch to solar power.

More recently, energy prices have skyrocketed. "There are taxes levied on sources of environmental pollution, and those taxes are passed along in higher prices," says Dr. Neville Marzwell, technical manager of the Advanced Concepts and Technology Innovations program at NASA's Jet Propulsion Laboratory in California. "Additionally, many power plants are aging and need to be replaced. The cost of building or remodeling these structures also is passed along to the consumer. Nuclear power plants are being de-commissioned. The combination of increased operating expenses and increased demand means that energy is going

to cost more. In California, for instance, electricity now costs between 60 and 80 cents per kilowatt-hour.

Marzwell feels that the cure for the problem is creating a good economical base so that solar energy is every bit as efficient and economical— maybe more so— than conventional energy sources. The magic is in creating high-efficiency solar collection devices. That's what the Space Solar Power project is all about.



Congress has commissioned NASA to create a program to focus concentration on producing clean, economical energy for our country. Once America's energy needs are under control, additional energy could be exported to the rest of the world as a source of revenue.

"Besides helping our energy needs on Earth, SSP can also work to re-fuel other satellites that currently have to be replaced because they're out of power. Communication and military satellites have a short life that could be greatly extended if we can get more energy to them. That would be another way SSP could be economical."

Depending on how supportive Congress is of SSP, the project could be fully functioning by 2020 to 2040, Marzwell says. "The Sun's energy is free, not like gas and oil, which are becoming scarce," he says. "The expense comes from the process of obtaining it. Our goal is to make that process both efficient and inexpensive, while producing nonpolluting energy."

Adapted from NASA's Space Operations Mission Directorate

Information in this article was accurate as of the publication date. For the latest updates about this project, visit the NASA homepage (http://www.NASA.gov).

Angles and Electricity

Teacher Sheet(s)

Objective: To measure the energy output of a photovoltaic cell under varying conditions.

Level: 5-8
Subjects(s): Science, Mathematics
Prep Time: Less than 10 minutes
Duration: One class period
Materials Category: Special Requirements

National Standards:
Science: 3c
Math: 12c, 13b
Technology (ISTE):
Technology (ITEA):

Materials:

- Photovoltaic (PV) cell
- DC meter
- Protractor

Related Links:
Site used for derivation of Lesson Plan
Solar Matters - Florida Solar Energy Center

Supporting Article:
Beaming Down Energy

Pre-Lesson Instruction: *(none)*

Background Information: *(none)*

Guidelines:

1. Read the article, "Beaming Down Energy."
2. Divide into teams of two to three students.
3. Provide each student with 1 photovoltaic cell, 1 DC meter, protractor, and reflectors.
4. Attach alligator clamps on the panel to the wires on the DC meter.
5. Connect the red clamp on the PV cell to the red clamp on the meter. Connect the black clamp on the PV cell to the black clamp on the meter.
6. Place PV cell in sunlight, read meter, and record reading.
7. Move PV cell to various angles, read meter, record.
8. Test cell at 0 degrees, 45 degrees, 90 degrees, and so on.

Discussion/Wrap-up:

- Did your results cause you to think of more questions to explore?
- How does this represent some of the problems with collecting solar energy on the Earth as opposed to collecting with a satellite?

Extensions:

- Repeat test at different times of the day and the year.
- Try this experimenting while simulating cloud coverage, or do the activity on a cloudy day.

Angles and Electricity

Student Sheet(s)

Materials:

- Photovoltaic (PV) cell
- DC meter
- Protractor

Procedure:

1. Attach the meter to the PV cell.
2. Using the ground as a baseline, tilt the PV cell toward the sun.
3. Observe the needle on the meter.
4. Measure at least 5 different angles using the protractor.
5. Record your results.

Angle	Meter Reading

Record time of day: _____